CROSSINGS
NEWSLETTER OF THE WOOD IN TRANSPORTATION PROGRAM

Issue 41 *Winter 2001/2002*

In This Issue

CONSIDERATIONS WHEN PAVING TREATED TIMBER BRIDGE DECKS

Summary

Increased awareness of the efficiencies of timber bridges has resulted in a surge of treated timber bridge construction in the United States. Asphalt pavement problems have appeared due to deck flexibility and/or shrinkage, excessive treatment, and timber treatment/paving material incompatibility. Proper treatment and correct paving design will ensure economical, long-term pavement performance, while minimizing negative environmental impacts.

1. Introduction

The quality and durability of asphalt paving on treated timber bridge decks are determined by three main factors: structural characteristics of the bridge superstructure, type and amount of wood treatment chemicals and solvents, and the asphalt paving system.

Large deck deflection and timber deck member shrinkage can cause serious pavement cracking. Residual treatment chemicals and/or solvents at the timber surface can cause pavement bleeding, softening, and de-lamination.

2. Structural Considerations

2.1 Bridge Superstructure Deck Systems

The three most common timber bridge deck systems in the United States are: timber plank decks, stress-laminated timber

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Considerations when Paving Treated Timber Bridge Decks . . . *continued from page 1*

decks, and glued-laminated timber panel decks. Timber plank decks are generally on low volume, unpaved road systems. Stress-laminated decks are usually longitudinal, without beams or stringers, and are stressed together into monolithic slabs where moisture induced expansion/contraction is spread across the entire deck width. Since the stressed deck is essentially a single unit, differential deflection between multiple members does not occur.

Glued-laminated timber panel decks have the highest incidence of asphalt paving problems resulting from structural factors. Unless mechanically interconnected, wheel loads will cause the glued-laminated deck panels to move independently of each other. If this displacement is large enough, it will result in reflective cracking of the asphalt pavement. In addition, drying shrinkage can open gaps at the deck panel interfaces, which can cause excessive asphalt pavement cracking.

2.2 Differential Deflection of Deck Panels

Asphalt paving is flexible enough that uniform bridge superstructure deflection seldom causes pavement problems. The most common cause of pavement failure in glued-laminated panel deck systems is differential deflections between adjoining deck panels. This is particularly true of transverse glued-laminated deck panel systems (the panels are installed with the laminations perpendicular to traffic flow). Wheel loads moving from panel to panel cause rapid, repetitive panel movement. When these deflections are greater than .05 inches the pavement will usually crack. When deflections exceed .10 inches the cracks will often ravel, causing impact loadings and increased moisture penetration and retention.

Designing stiffer glued-laminated panel decks, either through closer beam spacing or a thicker deck, will prevent deflection-induced pavement cracking. Traditionally, timber bridges were designed with flexible beams and stiff decks. The advent of glued-laminated timber allowed fabrication of deeper, stiffer beams. Larger beams encouraged greater beam spacing and more deflection in decks. Deeper deck panels minimize deflection and pavement cracking, but quickly increase the material cost of a timber bridge.

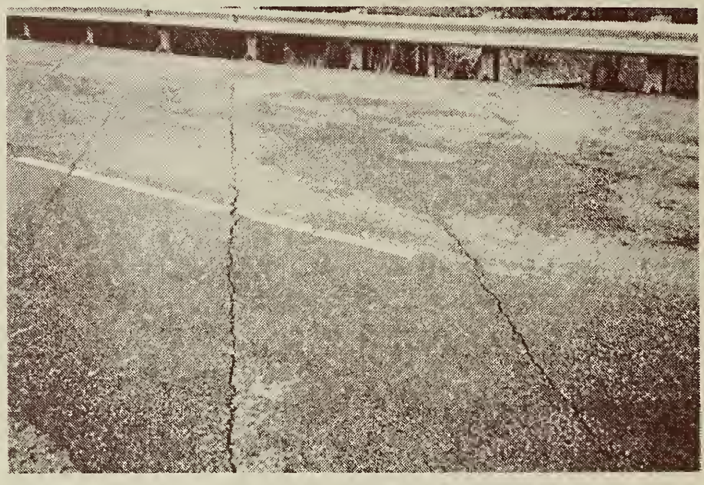

Figure 1. *Pavement cracking caused by differential deflection of panels.*

A more effective solution is often to mechanically interconnect the glued-laminated deck panels. The most common method of panel interconnection is the dowelled system developed by the USDA Forest Service Forest Product Laboratory in the 1970s. This system is described in the USDA Forest Service publication, *Timber Bridges: Design, Construction, Inspection, and Maintenance* [1]. A series of steel dowels are placed at the mid-depth of the glued-laminated panels. Design specifications are included in the American Association of State Highway and Transportation Officials, *Standard Specifications for Highway Bridges* [2].

Another interconnection system, which may be easier to install and more economical, is a longitudinal stiffener beam (load distributor beam) attached to the underside of the deck, midway between the longitudinal, load carrying beams. This stiffener beam should have a minimum stiffness of EI= 80,000 KIP-inches^2 and should be bolted through the deck near the edges of all glued-laminated panels [3].

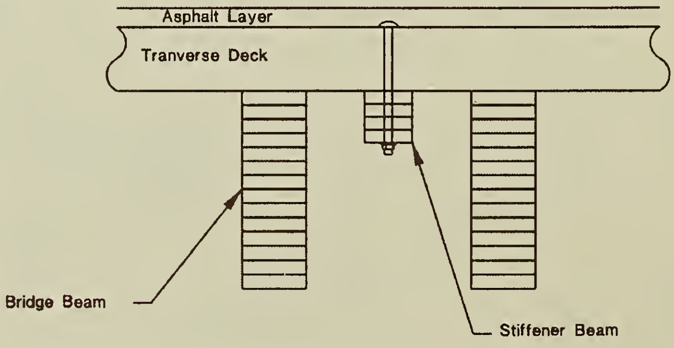

Figure 2. *Deck stiffener beam.*

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2.3 Shrinkage of Deck Panels

Glued-laminated deck panels are normally treated with oil-borne preservative treatments, thereby minimizing moisture penetration and the associated volume change. However, if deck panels are treated with waterborne treatments, or light oil solvent treatments in low humidity states, drying can cause enough deck shrinkage to crack asphalt paving at the panel joints. Deck panel expansion seldom causes pavement damage, but shrinkage of .125 inches per panel joint is enough to cause crack formation. A reduction in moisture content of as little as 3 percent can cause .375 inches of shrinkage in a 4-foot wide glued-laminated deck panel [4].

Figure 3. Pavement cracking caused by shrinkage of deck panels.

3. Treatment Considerations

3.1 Treatment Types

The most common oil-based treatments are creosote, pentachlorophenol, and copper naphthenate. Creosote for bridge timber should be derived entirely from coal tar, as required in AWPA P1/P13 [5]. Pentachlorophenol and copper naphthenate treatment chemicals can be carried in either a heavy oil solvent (AWPA Type A) or a light oil solvent (AWPA Type C). Type A solvent provides more protection against moisture intrusion and is usually preferred by bridge engineers. However, Type C solvent is often used in more sensitive environments as it provides a cleaner surface with less potential of solvent leakage.

When timber is improperly treated, or if post-treatment cleaning procedures are not followed, treatment chemicals (and/or solvents) will be present at, or may migrate to, timber surfaces. These materials have detrimental effect on asphalt pavement. Excessive creosote or oil solvent reduces pavement to deck adhesion, softens the asphalt in the pavement mix, and causes bleeding and pavement rutting.

3.2 Proper Treatment Practices

In 1994, the Western Wood Preservers Institute and the Canadian Institute of Treated Wood, in consultation with the USDA Forest Service, published a set of specifications for timber treatment. The latest edition of this publication, *Best Management Practices for the Use of Treated Wood in Aquatic Environments* [6] (BMPs) was printed in 1996. These specifications seek to minimize the amount of treatment chemicals available to migrate into the environment by controlling treatment procedures, mandating post treatment cleaning procedures, limiting chemical loading, and requiring visual inspection before installation. (The BMPs can be viewed at *www.wwpinstitute.org*.)

These specifications were prepared to protect the quality of water and diversity of various life forms found in the lakes, streams, estuaries, bays, and wetlands of North America. A secondary result of complying with these specifications has been improved performance of asphalt pavements on treated timber bridge decks treated in compliance with the BMPs.

Figure 4. Bleeding caused by over treatment (note tracking from bridge to approach).

In 2000, the USDA Forest Service, Forest Products Laboratory inspected and measured preservative retention levels in four creosote treated bridges in

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Michigan [7]. Two of these bridges had undergone post treatment procedures as required by the BMPs. The other two bridges had not. Core samples revealed similar creosote retentions in all four bridges. The two bridges not receiving post treatment procedures exhibited excessive underside leakage of creosote, bleeding of asphalt/creosote on the roadway surface, and pavement rutting. The two bridges receiving a post treatment cleaning procedure had none of these problems.

4. Pavement System Considerations

4.1 Paving Membranes

Concern about water penetration causing wood deterioration, and dissolved roadway salts causing steel component rusting, has prompted widespread use of waterproof paving membranes as part of asphalt paving systems on many treated timber bridges. Paving membranes are basically paving fabrics, or fiber mesh, impregnated with polymer modified, or rubberized asphalt. Indiscriminate use of paving membranes has caused installation, durability, and environmental problems.

4.2 Installation

One side of most paving membranes is sticky and is designed to adhere to the bridge surface. These membranes were developed for concrete bridge decks where the hot asphalt overlay melts the membrane, filling surface voids in the concrete and tightly bonding the asphalt overlay to the bridge deck surface. A primer, or sealer, is often recommended for the concrete surface to improve the bond. This process results in a waterproof seal of the concrete bridge deck, which is very important since concrete is susceptible to damage from intrusion of water and dissolved roadway salts. In most cases, properly preservative treated timber decks are not nearly as susceptible to moisture and salt damage.

Treated timber bridge decks present a significantly different installation challenge. Oil-borne preservative treated timber decks will not absorb the melted paving membrane. Timber decks also do not absorb and dissipate the heat of the asphalt overlay as readily as concrete. When an oil-borne preservative treated timber deck bridge, with a paving membrane is paved, a semi-liquid pool of rubberized asphalt forms between the deck and the overlay. This often causes the entire membrane to slip under the overlay, folding and bunching the fabric in front of the paving machine. The melted asphalt either drips through the timber deck or remains at the wood pavement interface. This concentration of asphalt will soften asphalt pavement and cause ongoing problems.

4.3 Durability and Environmental Concerns

Over the past several years, incidents of asphalt material dripping from the underside of treated timber deck panels have been reported in Michigan and Oregon. In July of 2000, a creosote treated transverse glued-laminated timber panel deck bridge in Michigan was inspected and tested. The bridge had been paved in late November of 1998. Immediately after paving, strands of melted paving membrane were observed hanging from the underside of the bridge. The hot asphalt overlay melted the paving membrane causing this initial leakage. However, the membrane continued to leak from the underside of the bridge.

In early 2000, two Forest Service bridges in Oregon were reported to be leaking asphalt material between the deck panels. One bridge had been installed in 1991, the other in 1998. In each case the leakage was not observed until the bridges were inspected in the fall of 1999. Deck panels for the 1991 bridge were treated with pentachlorophenol in a light oil solvent. The deck had been coated with an asphalt primer before installing the paving membrane and asphalt pavement. The deck panels for the 1998 bridge were treated with pentachlorophenol in heavy oil and again coated with a primer before placing the membrane and asphalt pavement.

The creosote and pentachlorophenol treatment solvents in all these bridge decks appear to be dissolving the asphalt in the paving membranes. The Michigan bridge deck panels were not post treatment cleaned, and significant quantities of creosote were present on the panel surfaces. For the Michigan bridge, it appears that the paving membrane began to dissolve almost immediately after placement of the overlay. The Oregon bridges were post treatment cleaned and the dissolved membrane leakage did not appear until

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one year after paving and eight years after paving. The primers, and the light oil solvent used in the 1991 Oregon bridge, may have affected the time at which the dissolved material appeared. Several additional copper naphthenate treated timber bridges in western Oregon were also observed actively leaking dissolved paving membrane rubberized asphalt when inspected in November of 2000.

In 2001, tests were conducted on three different paving membranes. The membranes were submerged in four solutions: 1) a light oil solvent (AWPA Type C), 2) pentachlorophenol in light oil solvent, 3) copper naphthenate in light oil solvent, and 4) a heavy oil solvent (AWPA Type A). The light oil solutions dissolved all of the asphalt in the paving membranes within three days. The heavy oil solution dissolved all of the asphalt in the paving membranes in about two weeks. The resulting solutions from the light oil only and heavy oil only solutions contained finely ground rubber particles. The pentachlorophenol and copper naphthenate light oil solutions appeared to have dissolved the rubber particles, as well as, the asphalt material.

Both light and heavy oil treatment solvents (AWPA Types C and A) readily dissolve asphalt. Pentachlorophenol and copper naphthenate chemicals appear to also dissolve the ground rubber, which is added to paving membranes to increase water resistance. Past experience has shown that creosote chemicals will also dissolve the rubber compounds. Whether or not the rubber is dissolved is probably irrelevant, since the finely ground rubber particles will flow with the dissolved asphalt.

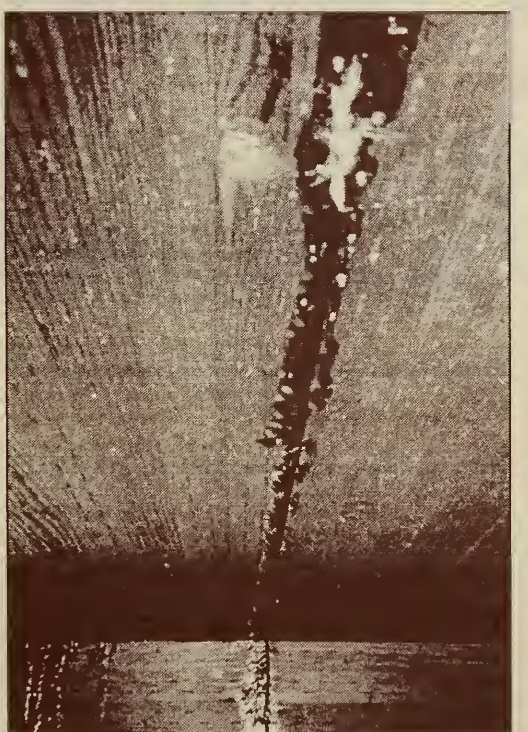

Figure 5. Paving membrane leakage.

If timber treatment solvents and asphalt are both present at the treated wood/asphalt-pavement interface, the asphalt will dissolve. If enough solvent and asphalt are available, the dissolved asphalt will flow down through any available opening and also migrate up through the asphalt paving. The downward flow causes environmental concerns and the upward migration causes pavement softening, rutting, and bleeding at the pavement surface.

Paving systems using membranes are difficult to install on treated timber bridge decks and can cause softening of the asphalt, as well as environmentally inappropriate and unsightly leakage if placed directly against any oil-borne preservative treated wood.

4.4 Paving Recommendations

Oil-borne preservative treated timber decks are very resistant to moisture penetration and damage, particularly if a bituminous sealer is placed between the vertical joints of the glued-laminated deck panels. This creates a waterproof cover over the beams and hardware. Constructing the bridge on a minimum road grade of one percent will also help keep the bridge dry. However, if road salts are present, a waterproof paving system may be necessary to fully protect critical steel components such as stressing bars, beams, and connection hardware.

Paving membranes should not be placed directly against oil-borne preservative treated wood; however, they can be used over a base layer of asphalt. A crowned 1.5- to 2-inch layer of asphalt should be placed directly on the treated timber bridge deck. The paving membrane is then applied, and a final 1.5- to 2-inch layer of asphalt is placed over the membrane [8].

Another waterproofing system is to spray a light coat of rubberized asphalt cement, with or without a paving fabric, directly onto a clean treated timber

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deck before placing the asphalt overlay. This asphalt seal will provide an effective water resistant layer, provided the bridge deck is on a grade to prevent surface water from ponding.

Asphalt pavements are compatible with oil-borne preservative treated wood only when minimal amounts of asphalt and/or treatment solution are present at the wood/asphalt-pavement interface.

5. Conclusions and Recommendations

Unless glued-laminated deck panel deflection is limited to .05 inches, panels should be mechanically interconnected. Deck panels should be treated with an oil-borne preservative, and to minimize shrinkage, should be installed at moisture contents of 16 percent or less. Deck panels should be treated in compliance with the treatment Best Management Practices to minimize solvent and treatment chemical surface migration. The quantity of asphalt at the wood/asphalt-pavement interface should be minimized and paving membranes should not be placed in direct contact with oil-borne preservative treated wood.

6. References

[1] Ritter M. A., Timber Bridges: Design, Construction, Inspection, and Maintenance, 1990, EM 7700-8, 944 pages.

[2] American Association of State Highway & Transportation Officials, Standard Specifications for Highway Bridges, 1996, pp. 38-39.

[3] Wacker J. P., and Smith M. S., Standard Plans for Timber Bridge Superstructures, 2001. FPL-GTR-125, Madison, WI: USDA, FS, FPL. 53 pages.

[4] Forest Products Laboratory. Wood Handbook: Wood as an Engineering Material, Agriculture Handbook 72, pp. 3-16, 3-17.

[5] American Wood Preservers' Association, American Wood Preservers' Standards, 1997.

[6] Western Wood Preservers Institute, Best Management Practices for the Use of Treated Wood in Aquatic Environments, 1996.

[7] Wacker J. P., Crawford D. M., Eriksson M. O., Foster D. O., Sikarski D., Investigation of Michigan's Creosote Treated Timber Bridges (*In Press*). FPL-GTR-, Madison, WI: USDA, FS, FPL.

[8] Weyers R. E., Loferski J. R., Dolan J. D., Haramis J. E., Howard J. H., Hislop L., Guidelines for Design, Installation, and Maintenance of a Waterproof Wearing Surface for Timber Bridge Decks, 2001. FPL-GTR-123, Madison, WI: USDA, FS, FPL. 15 pages.

— **Merv Eriksson, P.E.**
USDA Forest Service

A similiar paper was prepared and presented at the International Association for Bridge and Structural Engineering Conference, Lahti, Finland, August 29-31, 2001.

Student Design Competition

Application Deadline is April 12, 2002

For student chapters of the Forest Products Society and American Society of Civil Engineers, there is still time to enter the annual timber bridge student design competition. **Deadline is April 12, 2002.** For additional details, visit the following website: *http://www.msrcd.org/bridge.htm*

NATIONAL TIMBER BRIDGE AWARDS COMPETITION

If you're involved in the design or construction of a timber bridge, you may want to consider entering your favorite bridge project in this national competition. The competition highlights innovative and efficient uses of wood products to help solve bridge problems in America's highway infrastructure. Bridges will be judged on the basis of their design innovation, visual appeal, cost effectiveness and sound engineering principles. **Entry deadline is April 30, 2002.**

Eligibility

Timber bridges must have been in service prior to December 31, 2001. Any specifier, designer, owner or contractor involved in creating a modern wood bridge is eligible for the awards.

Sponsors

Primary sponsors are APA – *The Engineered Wood Association*, American Institute of Timber Construction, the U.S. Forest Service-Wood In Transportation Program, and the Federal Highway Administration. Supporting sponsors are American Wood Preservers Institute and *Roads & Bridges Magazine*.

Criteria

Bridges will be judged on the basis of their design innovation, visual appeal, cost effectiveness and sound engineering principles. The competition highlights innovative and efficient uses of wood products to help solve bridge problems in America's highway infrastructure.

Award Categories

The 2001 National Timber Bridge Awards will be presented in five categories:

- Pedestrian/light vehicular bridges
- Vehicular bridges with main span over 40 feet
- Vehicular bridges with main span under 40 feet
- Covered bridges
- Rehabilitation of existing bridges using wood components

Entry Requirements

All entries must be submitted on an official entry form with photographs and a written description of the bridge. Photos should be high quality 8" by 10" color prints, or color slides. All photos must be released for use by the Timber Bridge Awards Program.

In describing the project, include problems encountered, innovative solutions, research conducted, and cost evaluations. When possible, include 8-1/2" by 11" drawings showing bridge elevation, framing systems and typical details.

Presentation

Submit your entry in an 8-1/2" by 11" format with materials preferably displayed in transparent window sleeves. Do not submit full size engineering drawings.

Judges

A panel of judges representing a wide diversity of timber bridge design expertise will evaluate all entries.

Award Notification

Winners will be notified by the sponsors. There will be First Place Award winners and Award of Merit winners selected for all five categories. Award plaques will feature a color photo of the winning bridge and names of its designer, contractor, and owner or sponsor. Materials from non-winners will be returned. Award winners will be publicized nationally.

Deadline

If you have additional questions, contact APA – The Engineered Wood Association at 253-620-7407. Entries must be postmarked by *April 30, 2002*. Send them to the attention of:

National Timber Bridge Awards
APA – *The Engineered Wood Association*
7011 S. 19th Street
Tacoma, WA 98466
Attn: Tom Williamson

For a copy of the application form, visit the National Wood In Transportation Information Center website at: *www.fs.fed.us/na/wit* and click on ***National Timber Bridge Awards.***

NEW PUBLICATIONS

Potential for Expanding Small-Diameter Timber Market: Assessing Use of Wood Posts in Highway Applications

There is an over-abundance of small-diameter timber available in the United States. There is low demand for this material because it has low value. One way to increase the value, and therefore the demand, for this material is to develop or expand markets where the material can be used. One such market is that of wood posts in highway applications. In this study, we gathered information on the current use of posts, both wood and those made from other materials, used in highway applications. Information was gathered using a survey of Department of Transportation engineers from across the United States. We then analyzed the information to assess the possibility of increasing the use of small-diameter timber in the highway application market. We found many opportunities for ways this market could be expanded, but we also found challenges to increasing this market.

To obtain a copy, please contact the National Wood In Transportation Information Center at 304-285-1591 and request publication number WIT-09-0014, or visit the following website: *http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr120.pdf.*

Under Development - Portable Timber Bridge Publication

The staff at the National Wood In Transportation Information Center is developing a publication on portable timber bridges. We will be highlighting several successful portable bridge projects that the program has assisted with in the past. Within the publication, we plan to include a comprehensive list of portable timber bridge manufacturers throughout the country. If your firm manufactures portable timber bridges or you know of a firm that does, please let us know. You can e-mail us with the information to: *mstrother@fs.fed.us* or call the National Wood In Transportation Information Center at 304-285-1591.

Article contributions, questions, or comments may be sent to Ed Cesa, Program Coordinator, National Wood In Transportation Information Center or Mr. Chris Grant, Program Assistant, USDA Forest Service, 180 Canfield Street, Morgantown, WV 26505; Phone: (304) 285-1591; FAX: 304-285-1587, or e-mail cgrant@fs.fed.us. A change of address may also be submitted to cgrant@fs.fed.us. For publication requests, e-mail jnorth@fs.fed.us.

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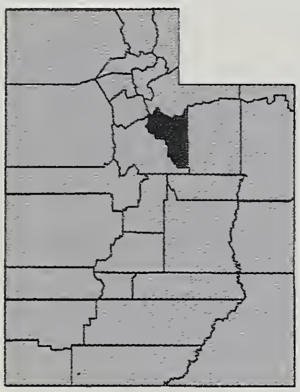
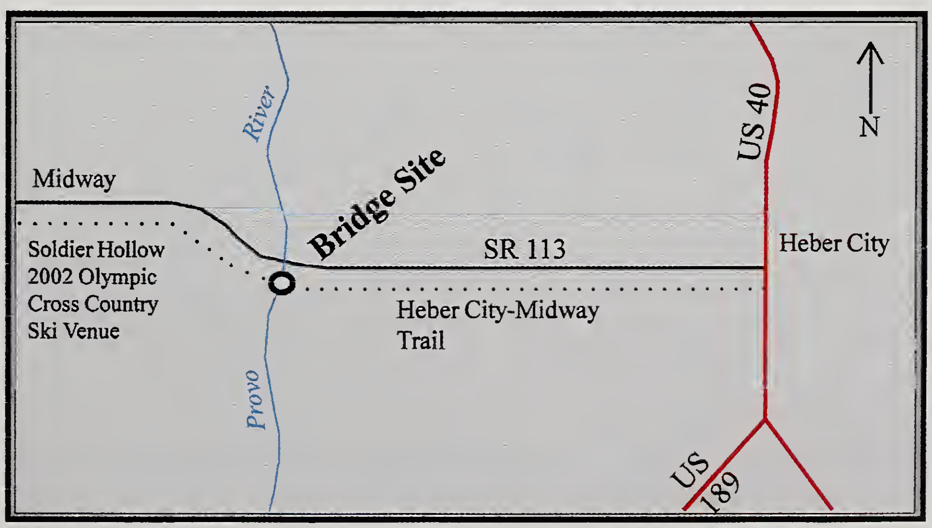
PROVO RIVER PEDESTRIAN COVERED BRIDGE, Wasatch County, Utah



Type: Covered pedestrian bridge with glued-laminated/fiber reinforced polymer wood beams and transverse glued-laminated deck
County: Wasatch
Owner: Wasatch County
Built in: 2001
Fabricator: Perma Post Products & Euclid Timber Frames
Engineer: Merv Eriksson, USDA Forest Service
Architect: George Olson, Architect, Midway, UT
Spans over: Provo River
Bridge length: 125'-1" (2 spans)
Roadway width: 12'-0"

Directions: The bridge carries the Heber City-Midway Trail over the Provo River between Heber City, UT and Midway, UT. The trail parallels State Route 113.



GEOMETRY

Number of Spans: 2
Out-to-out length: 125'-1"
Center-of-bearing length: 124'-5"
Skew: 0 degrees
Out-to-out width: 13'-5-1/2"
Rail-to-rail width: 12'-0"
Number of beams: 4
Superstructure square footage: 1683

Design loads: Snow load - 50 lbs/sq. ft. (on roof); Pedestrian load - 65 lbs/sq. ft. (on deck); H10 vehicle load
Design by: Merv Eriksson, USDA Forest Service

Total wood quantity: 33,000 bf
Wood quantity in bridge cover: 11,850 bf
Wood quantity in remainder of bridge: 21,150 bf
Total structure cost: $155,000
Total substructure cost: $30,000
Total superstructure cost: $125,000
Total superstructure cost /sq. ft.: $74.27

MATERIAL

DECK
Material: Glued-laminated wood
Species: Coastal Douglas-fir
Size: 3'-8" x 48" x 12'-0" panels
Preservative treatment: Pentachlorophenol in light oil

STRINGERS
Material: Glued-laminated wood
Species: Coastal Douglas-fir
Sizes: Interior - 6-3/4" x 42"; Exterior - 8-3/4" x 54" fiber reinforced with Kevlar
Preservative treatment: Pentachlorophenol in light oil

COVER/HANDRAIL
Material: Rough sawn wood
Species: Douglas-fir
Quantity: 11,850 bf
Preservative: Wood sealer
Connections: Mortise and tenon and wood pegs

ABUTMENTS
Helical screw pile abutments
Glued-laminated abutment caps
Reinforced concrete pier supported by helical screw piles

BRIDGE PERFORMANCE: This bridge is part of a non-motorized trail connecting the towns of Heber City and Midway, Utah, and in the future will also connect to the Soldier Hollow Nordic Skiing Venue and the Uinta National Forest.

FUNDING SOURCES: USDA Forest Service: $50,000; Balance of funding from Mitsubishi Motor Corporation, Wasatch County, USDOT Federal Highway Administration, Utah Department of Transportation, and other partners. The project funding includes the Provo River Bridge, the nearby Spring Creek Bridge and the trail system.

LOCAL CONTACT: Robyn Pearson, Executive Director
Wasatch Economic Development Organization
475 North Main, PO Box 427
Heber City, UT 84032
Phone: 435-654-3666

Information provided by Merv Eriksson, USDA Forest Service

WIT Program Proposal Number: R04-001-00-PED   Federal Grant Identifier: 00-DG-11244225-141

October 2001

PARTNERS

Mitsubishi Motor Corporation, Wasatch County, USDOT Federal Highway Administration, Utah Department of Transportation, Heber Valley Chamber of Commerce, Tread Lightly!

USDA Forest Service: National Wood In Transportation Program, Uinta National Forest, Wasatch-Cache National Forest, 2002 Olympic Planning Team